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3430 BIOLOGICAL EVALUATION
R2-81-7

WESTERN SPRUCE BUDWORM ON THE PIKE AND SAN ISABEL, AND ARAPAHO AND ROOSEVELT NATIONAL FORESTS IN 1981

United States Department of Agriculture

Forest Service

Forest Pest Management
Denver, Colorado

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INTRODUCTION

The western spruce budworm is the most serious insect defoliator of Douglas-fir and white fir forest types in the Rocky Mountain Region. Historically, periodic epidemics have caused widespread and occasionally, locally severe defoliation. These epidemics may last from 5 to 15 years with tree damage dependent on the intensity and duration of the epidemic. During these periods, the budworm becomes a concern of forest land managers, mountain property owners, and various public groups.

Forest Pest Management monitors the western spruce budworm through annual aerial detection and egg mass surveys. These surveys are conducted to provide historical records of budworm activity within the Region and information on insect distribution and damage for concerned parties. In addition, a forecast of future budworm activity is made.

Since 1974, Douglas-fir stands on the Arapaho and Roosevelt National Forests have been sustaining damage from epidemic budworm populations. On the Pike and San Isabel National Forests budworm populations have fluctuated greatly since the early 1970's with an upward trend in recent years. However, tree damage has been less severe when compared with the Arapaho and Roosevelt National Forests. Current information indicates the insect will continue to cause measureable defoliation on these National Forests in 1982.

The surveys described in this report were conducted during July and August, 1981. The egg mass sample locations are permanent plots within areas of past and present chronic budworm activity. Not all budworm infested areas were sampled because of constraints on manpower and travel.

BIOLOGY OF WESTERN SPRUCE BUDWORM

The western spruce budworm, *Choristoneura occidentalis* Freeman, is the principal defoliator in spruce-fir forest types in the West. In Colorado, the budworm's preferred hosts are Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and white fir, *Abies concolor* (Gord. and Glend.) Lindl.. Subalpine fir, *A. lasiocarpa* (Hook.) Nutt., Engelmann spruce, *Picea engelmannii* Parry, and blue spruce *P. pungens* Engel., are also attacked.

The western spruce budworm has one generation per year in Colorado. Adult moths emerge and mate in July. Females may lay a partial compliment of eggs shortly after mating, the remainder are deposited after a dispersal period. Eggs are deposited in masses cemented to the undersides of host tree needles and hatch in ten days. The newly hatched larvae do not feed, but seek hiding places under bark scales on branches, in twig crotches, or among lichens where they spin silken shelters (hibernacula) and overwinter.

In the spring, larvae disperse to the foliage where they mine needles for one to two weeks. About the time buds begin to expand, larvae move into the buds and later, as the new shoots expand, spin loose feeding webs between shoots. Larvae prefer to feed on new foliage and become full grown in 30 to 40 days after feeding begins in the spring. Pupation takes place in feeding webs or on the foliage. Adult moths are not strong flyers, but may be carried considerable distances by air currents.

EXTENT OF OUTBREAK

The western spruce budworm occurs in all Douglas-fir and true fir forest types within the Region. The largest contiguous infestation occurs along the Front Range of Colorado, on the Pike and San Isabel, and Arapaho and Roosevelt National Forests and adjacent private lands. In 1981, approximately 1.4 million acres were infested in the Front Range.

	Infested Acreage	
Unit[1]	Moderate-Heavy[2]	Severe[3]
Pike National Forest	663 M	3 M
San Isabel National Forest	122 M	---
Arapaho National Forest	192 M	1 M
Roosevelt National Forest	366 M	28 M
TOTAL	1343 M	32 M

Acreages infested by budworm were determined from aerial sketch maps made at the time of peak defoliation.

HOST STAND CONDITION

Mature stands of mixed Douglas-fir and white fir in the southern Front Range and Douglas-fir in the northern Front Range have suffered extensive

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1/ Acreage figures include state, private, and other federal lands within or adjacent to Forest boundaries.

2/ Indicates moderate to heavy defoliation or 35-100% of the new growth.

3/ Indicates the occurrence of various amounts of top-kill and tree death as observed from the air.

and occasionally heavy defoliation (up to 100% of new growth) since the early 70's. The severity of tree damage caused by the western spruce budworm is directly related to the intensity and duration of defoliation. Stands displaying good vigor and growth can withstand occasional or possibly one or two consecutive years of heavy budworm feeding without significant injury. However, stands displaying poor vigor and growth (overmature and overstocked stands) will suffer varied amounts of tree injury depending on the intensity and duration of defoliation. Generally, budworm infestations cause varied amounts of tree deformity, seedling damage, seed destruction, and stand regeneration failure. Stands subjected to four or more consecutive years of heavy defoliation may incur top-killing, and an indeterminate amount of tree mortality principally in the smaller size class trees (<5" d.b.h.). Radial growth of defoliated trees may be reduced through the duration of the infestation. Recovery of defoliated trees is rapid. In as little as two to three years after the cessation of budworm feeding, most stands recover to near normal appearance.

EVALUATION METHODS

Egg mass surveys are the principal tool in evaluating budworm population trends and predicting defoliation. These surveys consist of sampling individual trees to estimate budworm egg mass density and defoliation. Sampling is accomplished using a fixed plot, cluster sampling scheme.

Sample plots were located within budworm infested areas on National Forest land. Plots consisted of three dominant or co-dominant Douglas-fir within close proximity. From each tree, two 27 inch foliated branches were pruned from the midcrown for a total of six branches per plot. These foliage samples were bagged, labeled, and transported to the laboratory to determine new egg mass densities. A stereoscope was used to segregate new from old egg masses.

Current year's defoliation estimates were made by pruning an additional two branches from each sample tree. These plus the egg mass sample branches were used to estimate defoliation. The new growth on 25 randomly selected twigs from each branch for a total of 100 twigs per sample tree, was examined in the laboratory for defoliation. Defoliation estimates are based on the percent of missing needles determined by an ocular examination. Egg mass and defoliation data were compiled and analyzed using a computer program developed by the Forest Service, Methods Application Group, Fort Collins, Colorado.

Defoliation predictions are based on egg mass densities. Density classes and associated predicted defoliation estimates are reported in Table 1. These classes are adopted from McKnight (1967) and refined based on four years data from the fixed plot, cluster tree, sampling scheme.

TABLE 1. Defoliation Prediction Classes for Western Spruce Budworm Egg Mass Sampling in Colorado

Class	Mean Number of New Egg Masses per Square Meter Foliage	Defoliation Prediction 1/
1	1.6 or less	Undetectable
2	1.7 to 10.0	Light
3	10.1 or more	Moderate to Heavy

1/ Defoliation expected on new growth only

Undetectable	0 - 10%
Light	10 - 35%
Moderate	35 - 65%
Heavy	65 - 100%

RESULTS

San Isabel National Forest. An aerial detection survey indicated approximately 122,000 acres of defoliation on both National Forest and adjacent private lands in 1981 (Figure 1). Detectable defoliation increased over 1980 principally on the west side of the Wet Mountains.

Egg mass sampling was limited to the Wet Mountains. Results are presented in Table 2. Egg mass densities from permanent sample plots on the Greenhill Divide and Oak Creek areas have increased over previous years. Over the past two years, these areas have shown increasing egg mass densities (Figure 2). Defoliation in 1982 is expected to be moderate to heavy in the vicinity of Oak Creek and light in the Greenhill Divide area. Both areas were lightly defoliated in 1981.

Pike National Forest. Egg mass surveys on this forest were conducted in three areas. Sampling results are presented in Table 3. Aerial sketch mapping revealed 663,000 acres of defoliation with 3,000 acres of severe defoliation on National Forest and adjacent private lands (Figure 3 and 4). Severe defoliation is defined as areas displaying top-killing and possible tree mortality as observed from the air. Severe defoliation on the Pike National Forest is confined to the south end of Rampart Range. Defoliation increased over 1980 principally in the vicinity of Elevenmile Canyon Reservoir.

Egg mass densities increased in all three sampling areas. Densities over the past four years are illustrated in Figure 2. Defoliation in 1982 is expected to be moderate to heavy in the vicinity of all three sampling areas, Little Scraggy Peak. Indian Creek, and Ormes Peak. In 1981, defoliation was moderate in the Little Scraggy Peak and Ormes Peak areas, while defoliation in the Indian creek area was light. Defoliation was not visible over the Indian Creek area at the time of aerial sketch mapping.

Roosevelt National Forest. Four areas were intensively sampled. Survey results are presented in Table 4. Aerial surveys indicated approximately 366,000 acres of defoliation with an estimated 28,000 acres in the severe catagory on National Forest and adjacent private lands (Figures 5 and 6). The severe defoliation occurred principally south of the Big Thompson River to Middle Boulder Creek.

Egg mass densities at the three permanent sample locations (Big Elk Meadows, Magnolia, and Devil's Gulch) declined from 1980 levels (Figure 7). Additional samples from the Estes Valley area (16.9 egg masses/M^2 foliage) were near 1978 levels[1/] (16.1 egg masses/M^2 foliage). Defoliation in 1981 was generally moderate to heavy with the exception of light defoliation in the Magnolia area. Defoliation in 1982 is expected to be moderate to heavy in the vicinity of all four sample areas (Big Elk Meadows, Magnolia, Devil's Gulch, and Estes Valley).

1/ Biological Evaluation R2-78-7, Western Spruce Budworm, Estes Valley 1978.

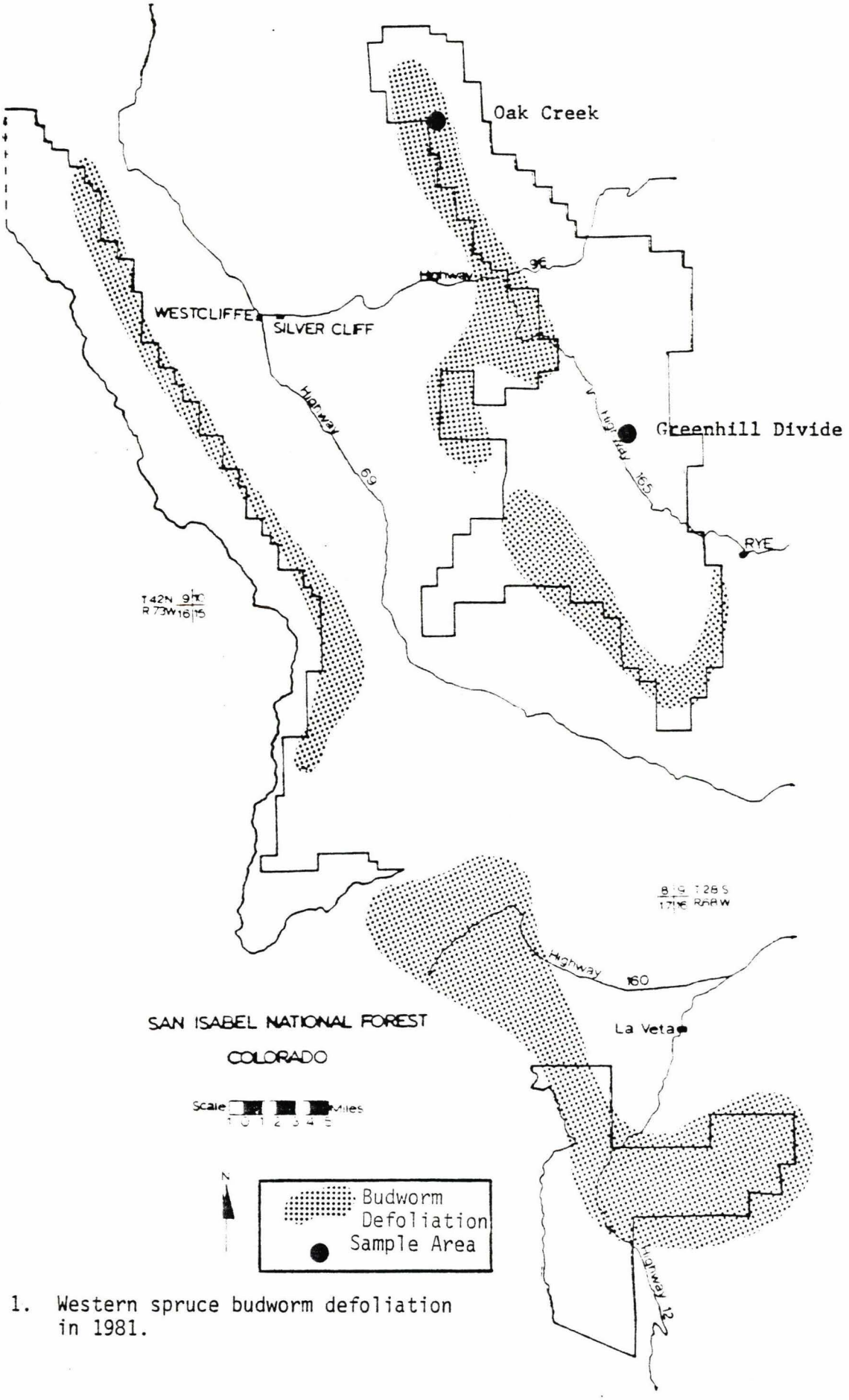

Figure 1. Western spruce budworm defoliation in 1981.

TABLE 2. Results of Egg Mass Sampling on the Wet Mountains of the San Isabel National Forest in 1981.

Area	Number of Branch Samples	Mean Number of New Egg Masses per Square Meter Foliage	1981 Defoliation Estimate	1982 Defoliation Prediction
Greenhill Divide	78	9.8	Light	Light
Oak Creek	30	13.5	Light	Moderate to Heavy
Summary	108	11.6	Light	Moderate to Heavy

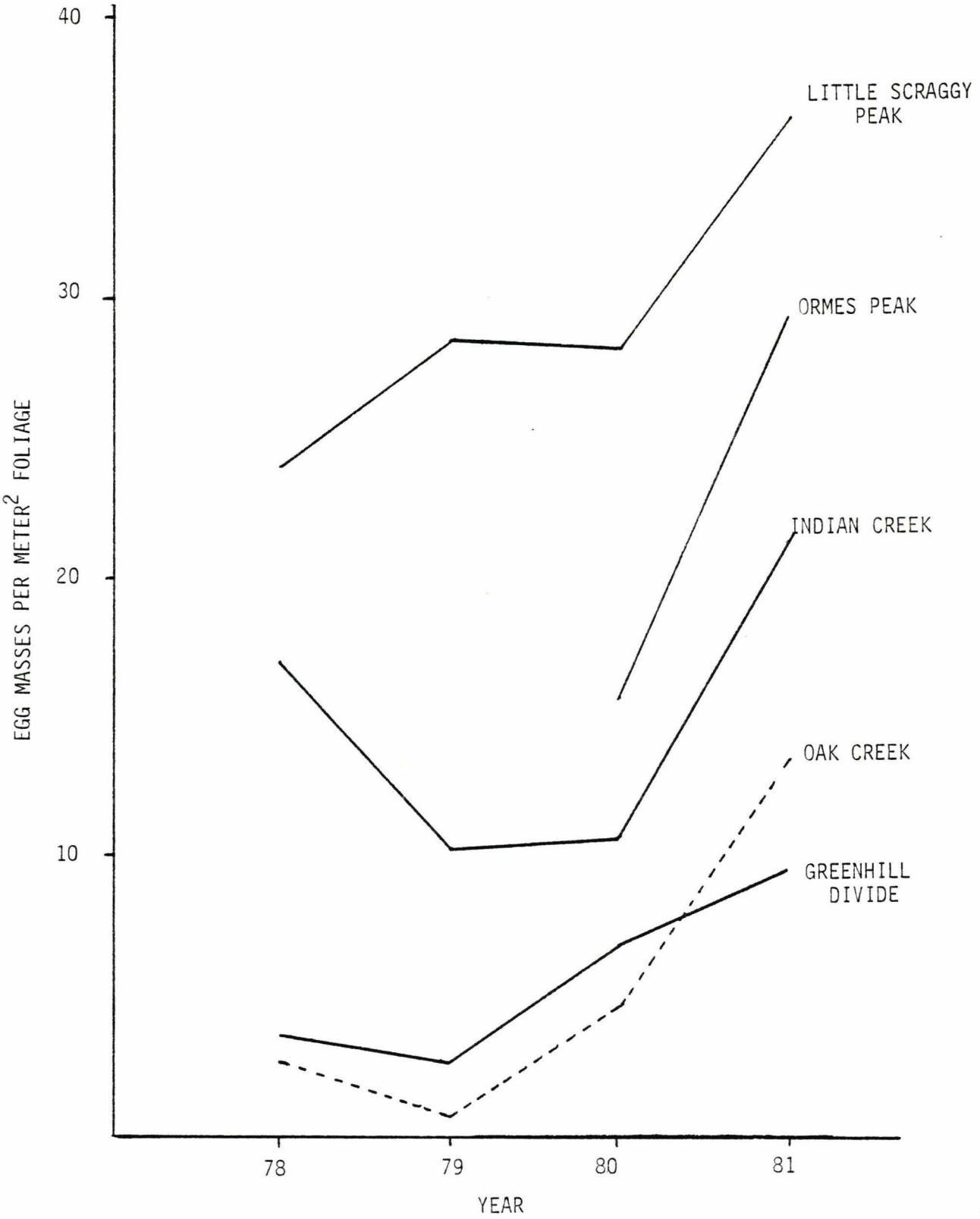

Figure 2. Western spruce budworm egg mass density trends for the Pike and San Isabel National Forests. Densities based on permanent sample plots.

TABLE 3. Results of Egg Mass Sampling on the Pike National Forest in 1981.

Area	Number of Branch Samples	Mean Number of New Egg Masses per Square Meter Foliage	1981 Defoliation Estimate	1982 Defoliation Prediction
Little Scraggy Peak	120	36.4	Moderate	Moderate to Heavy
Indian Creek	150	21.5	Light	Moderate to Heavy
Ormes Peak	30	29.5	Moderate	Moderate to Heavy
Summary	300	29.1	Moderate	Moderate to Heavy

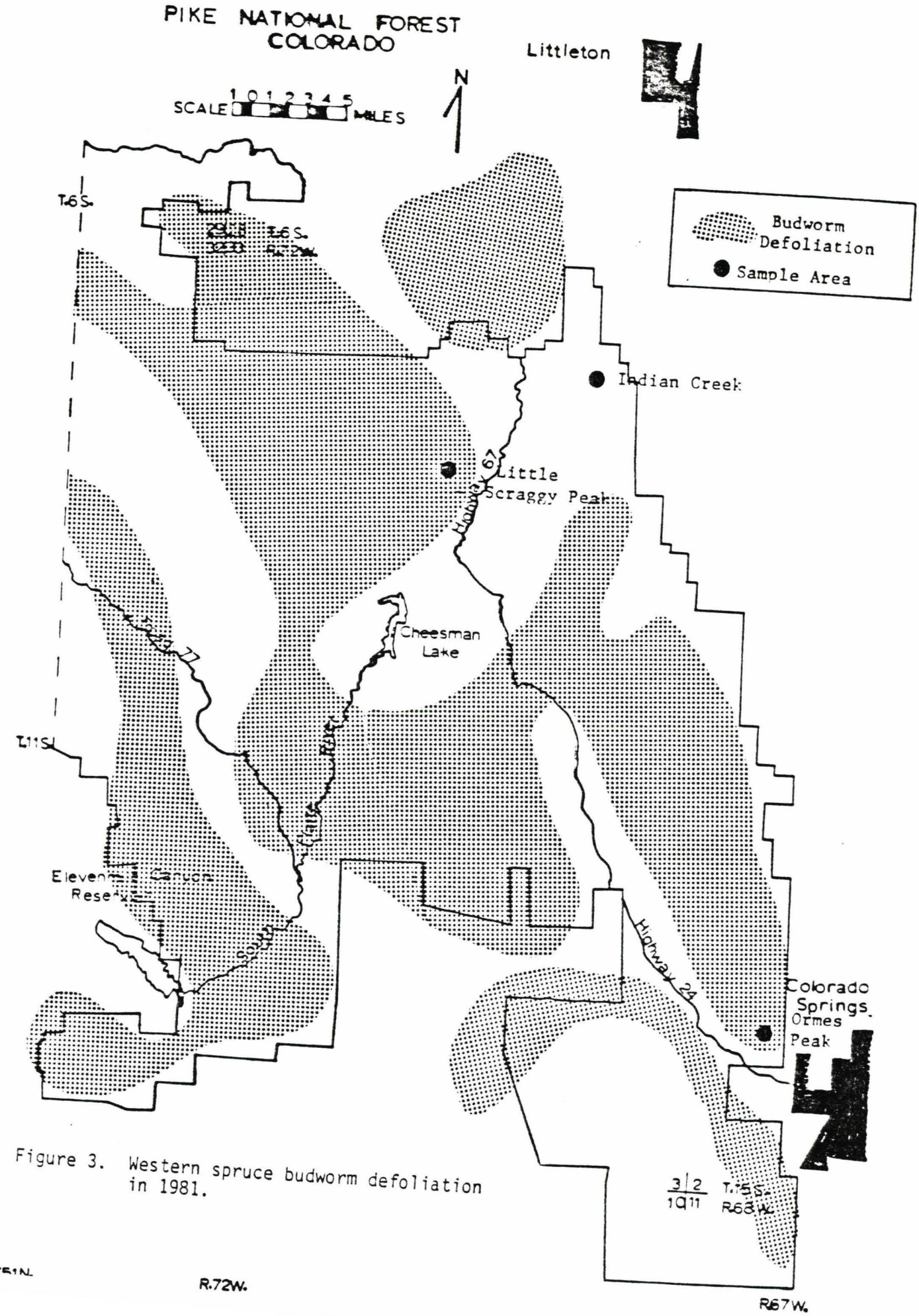

Figure 3. Western spruce budworm defoliation in 1981.

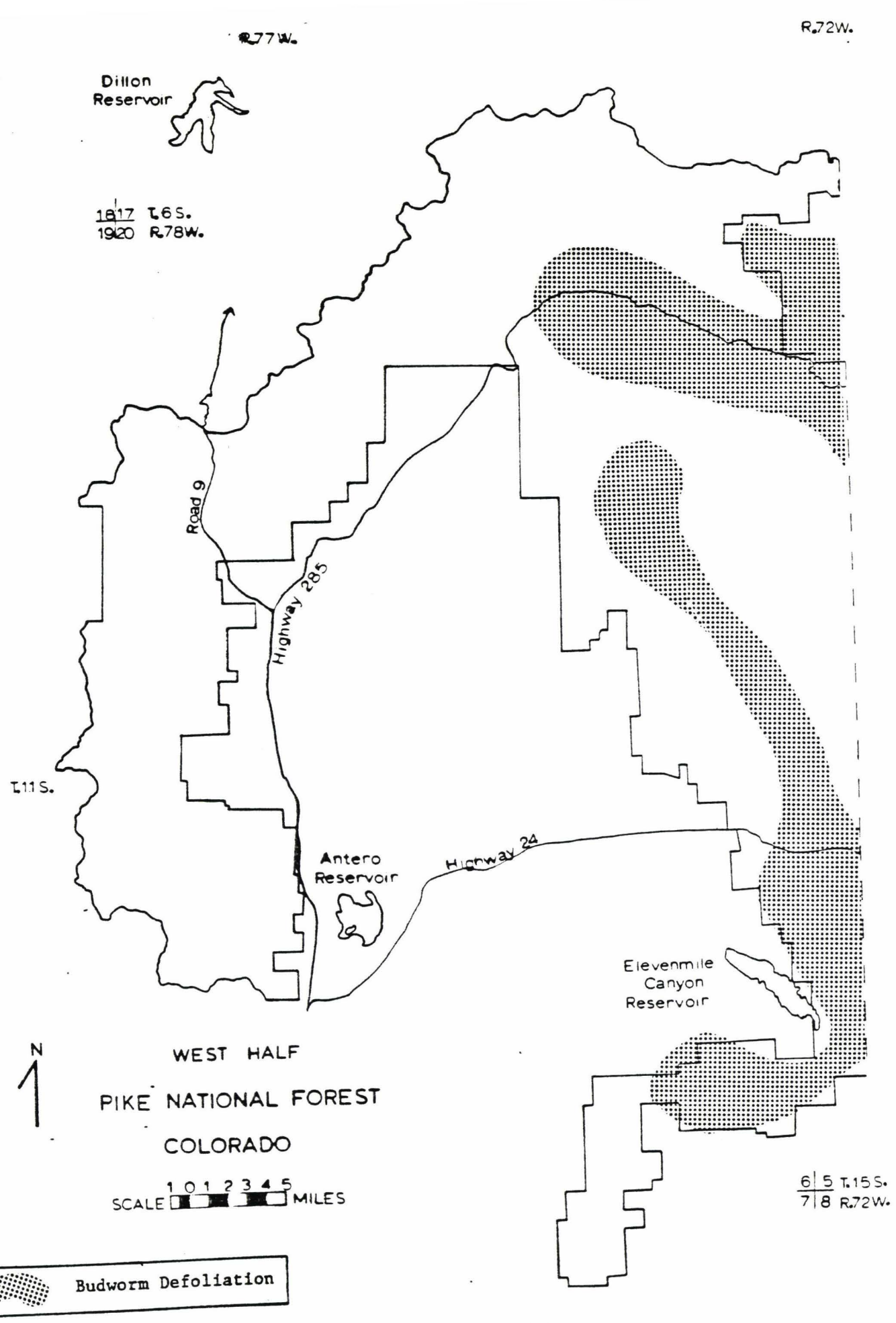

Figure 4. Western spruce budworm defoliation in 1981.

TABLE 4. Results of Egg Mass Sampling on the Roosevelt National Forest in 1981.

Area	Number of Branch Samples	Mean Number of New Egg Masses per Square Meter Foliage	1981 Defoliation Estimate	1982 Defoliation Prediction
Big Elk Meadows	120	40.3	Heavy	Moderate to Heavy
Magnolia	60	11.2	Light	Moderate to Heavy
Devil's Gulch	30	22.4	Moderate	Moderate to Heavy
Estes Valley Area	48	16.9	Heavy	Moderate to Heavy
Summary	258	22.7	Moderate to Heavy	Moderate to Heavy

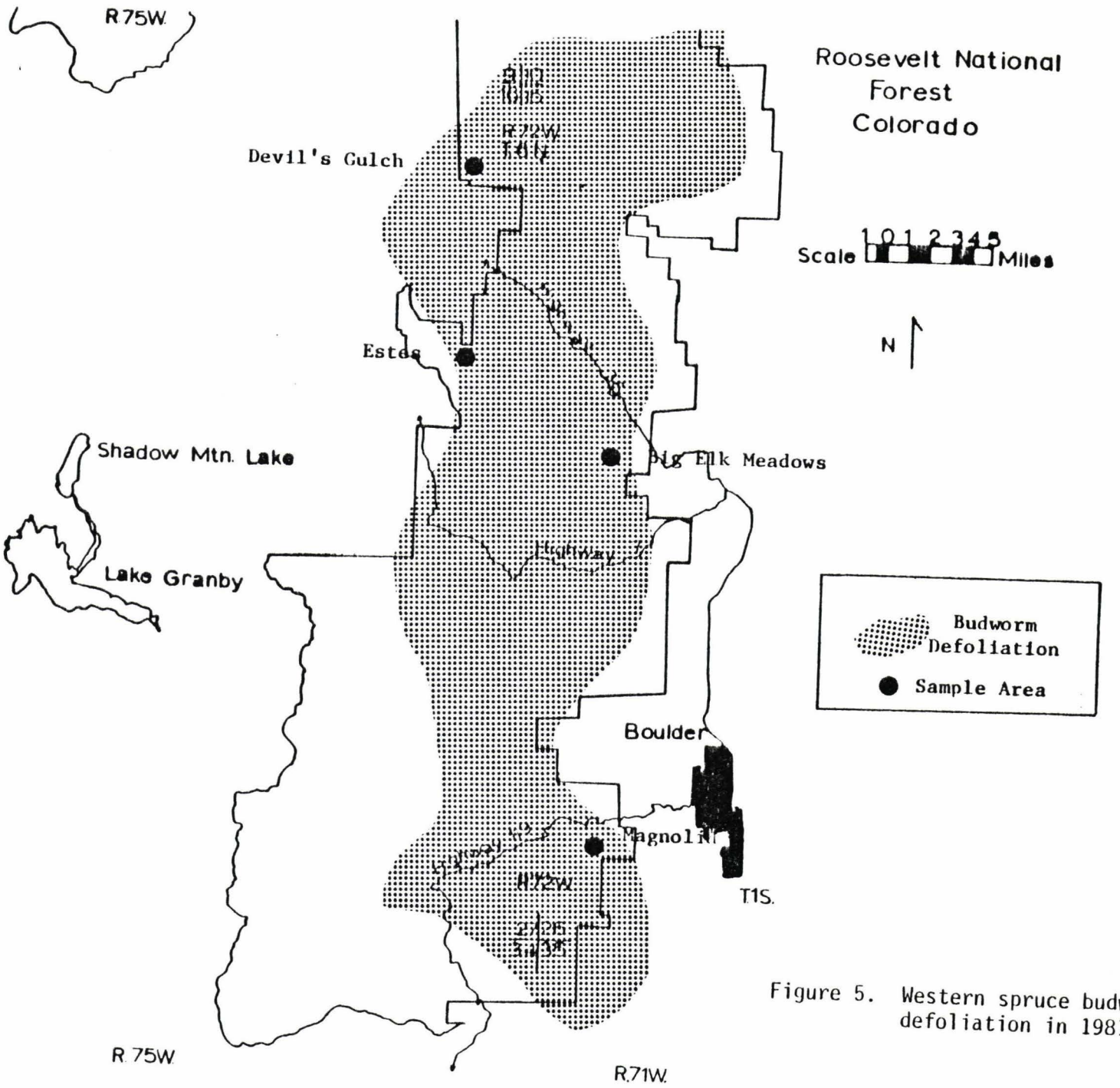

Figure 5. Western spruce budworm defoliation in 1981.

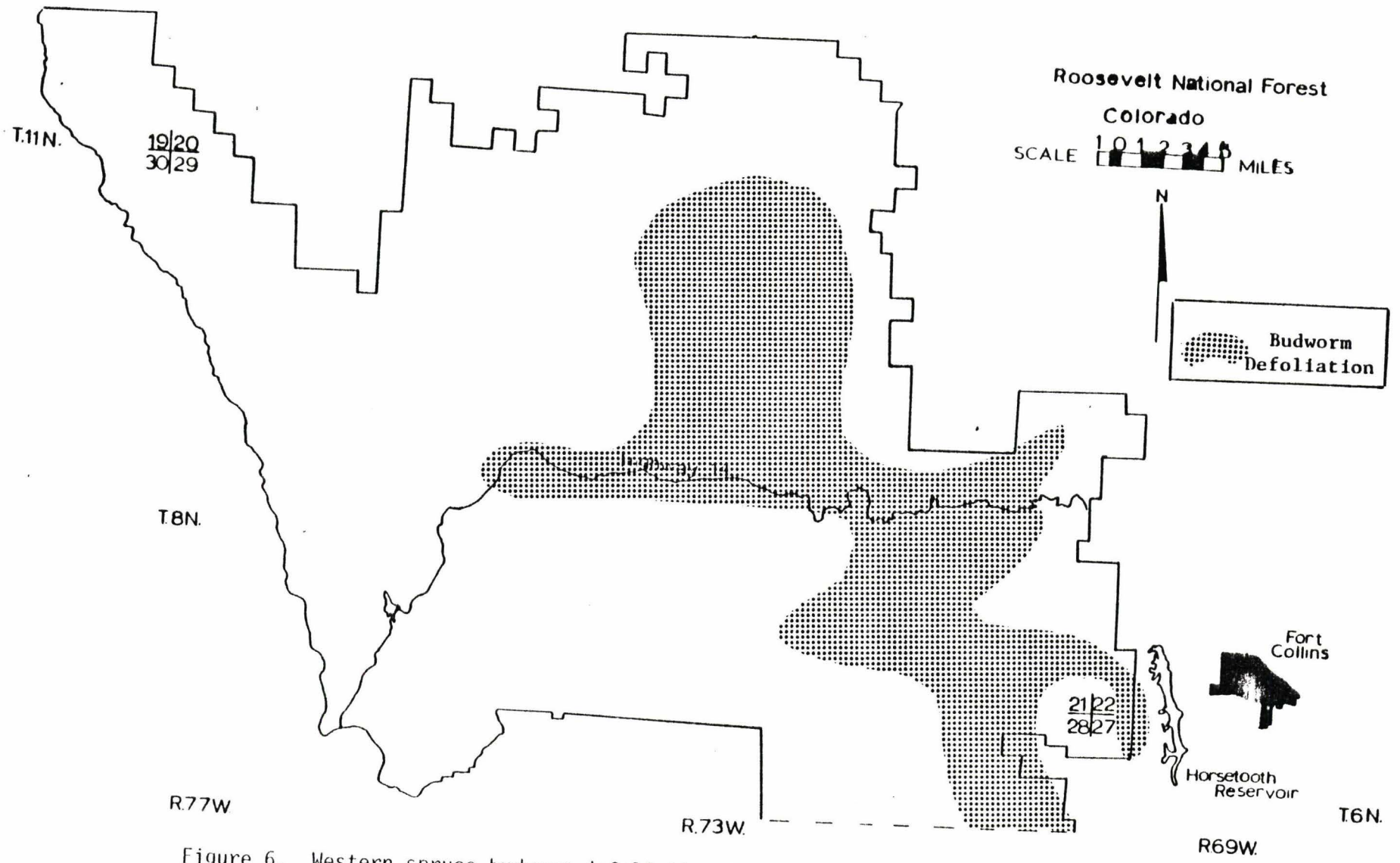

Figure 6. Western spruce budworm defoliation in 1981.

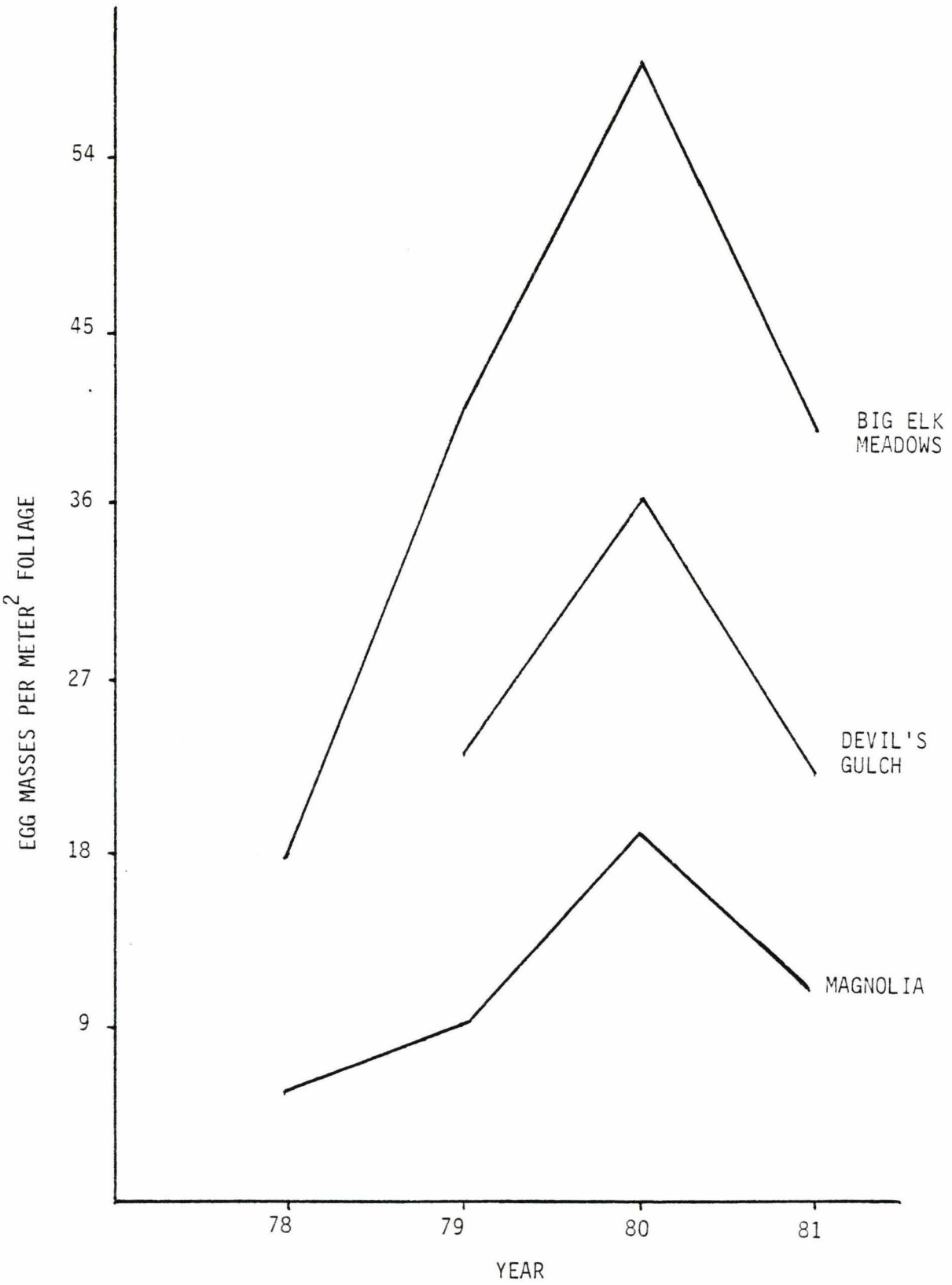

Figure 7. Western spruce budworm egg mass density trends for the Roosevelt National Forest. Densities based on permanent sample plots.

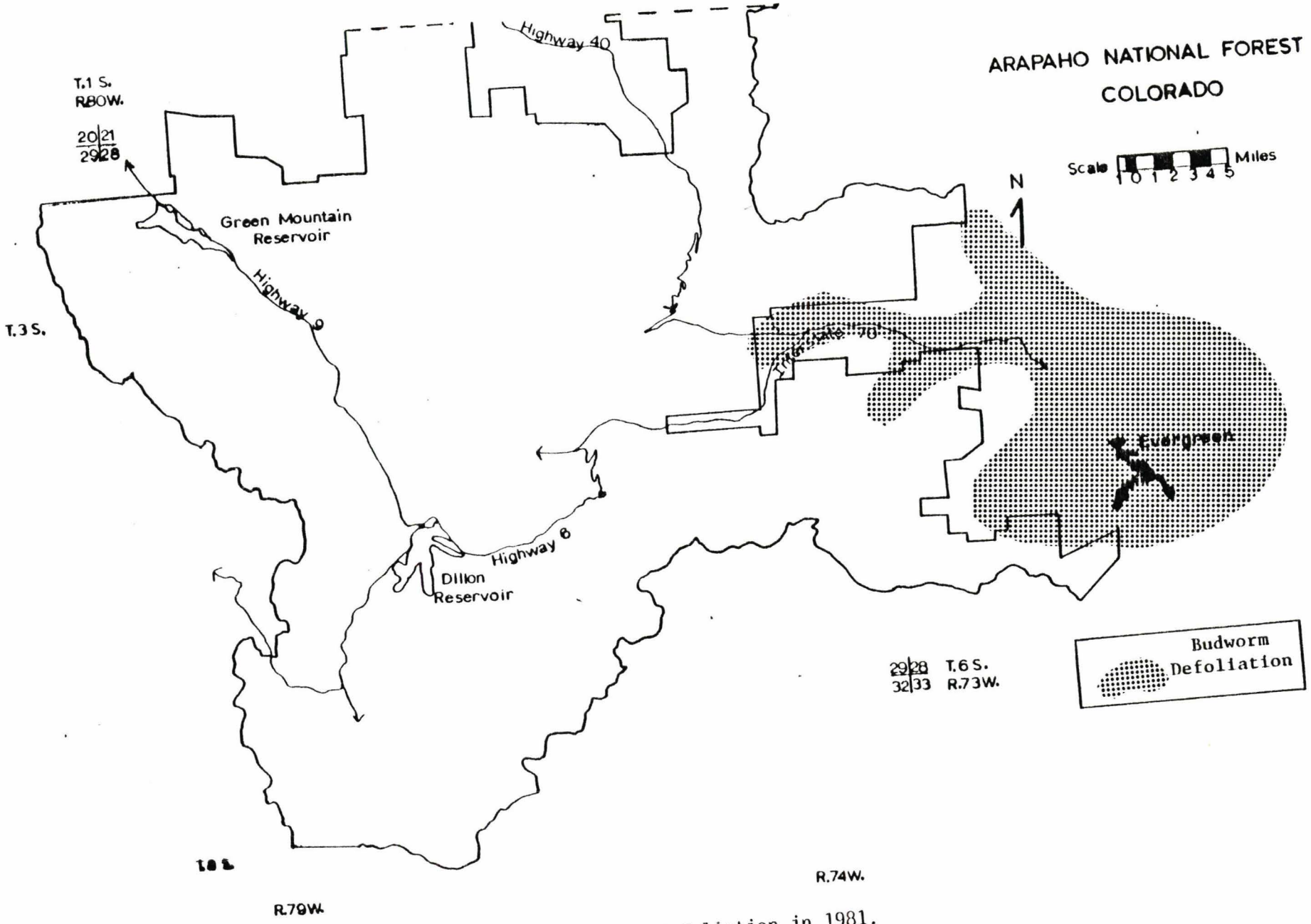

Figure 8. Western spruce budworm defoliation in 1981.

Arapaho National Forest. Aerial surveys determined approximately 192,000 acres of defoliation with 1000 acres of severe defoliation on National Forest and adjacent private land (Figure 8). The severe defoliation occurred principally on private lands in the Deer Creek drainage. The majority of budworm activity occurred on private lands with the exception of the Chicago Creek area. No egg mass density information was available for the Arapaho.

CONCLUSIONS

San Isabel National Forest. Budworm activity has increased with defoliated acreage nearing the early 1970's levels. For the Wet Mountains near Oak Creek and Greenhill Divide, egg mass densities were greater than 1980. Defoliation is expected to increase. Tree damage in these areas was slight and probably a result of severe defoliation in the late 1960's and early 1970's. Defoliation in the Spanish Peaks area has increased dramatically during the last two years. Budworm activity on the east side of the Sangre de Cristo's appeared chronic based on several years of aerial survey information, however severe tree damage was not apparent from the air.

Pike National Forest. Budworm activity has increased on this forest with egg mass densities and defoliated acreage up from 1980 levels. Moderate to heavy defoliation is expected to continue into 1982. In the areas sampled, tree damage was slight despite several years of defoliation. However, an aerial survey detected possible top-kill occurring on the south end of the Rampart Range. The occurrence of budworm related tree damage is expected to increase with continuing defoliation.

Roosevelt National Forest. Tree damage and defoliation was severe in Douglas-fir stands on this forest. Top-kill and some tree mortality has occurred in chronically infested areas. Budworm egg mass densities have decreased from 1980 levels in the sample areas. However, densities were still sufficiently high to predict moderate to heavy defoliation in 1982. Tree damage related to budworm feeding is expected to continue to increase in 1982.

Arapaho National Forest. The acreage defoliated on the Forest was small, with most budworm activity having occurred on adjacent private land. Visible defoliation increased sustantially over 1980, however, tree damage on National Forest land was not severe.

ALTERNATIVE ACTIONS

Alternative 1. No action. This alternative options for the natural course of events. Defoliation and subsequent tree damage are assumed acceptable. The insect epidemic will eventually decline as a result of natural factors.

Alternative 2. Suppression with Aerial Applications of Chemical Insecticides. A timely aerial application of chemical insecticides will protect foliage from defoliation. Application costs are approximately $8-12 per acre. Carbaryl, acephate, and malathion are registered specifically for use against the budworm. These chemicals are broad spectrum insecticides with low residual toxicities and breakdown rapidly after application. An effective aerial application may result in a budworm mortality rate of 90+ percent.

Alternative 3. Suppression with Aerial Applications of Microbial Insecticides. The microbial insecticide *Bacillus thuringiensis*, where properly applied, will protect foliage from defoliation, although results from prior applications elsewhere have been somewhat erratic. *Bacillus thuringiensis* or B.t. is a naturally occurring bacterium. It is a specific insecticide for the Order Lepidoptera (butterflys and moths). B.t. is environmentally safe. It has no demonstrable impact on nontarget organisms. Costs are estimated at $12-18 per acre for aerial application. The B.t. formulations Dipel[2/] and Thuricide[2/] are registered for aerial application.

Alternative 4. Protection of Individual High Value Trees with Insecticides. Individual trees of high value, such as those in campgrounds and picnic grounds, can be protected from defoliation by an application of either a chemical or microbial insecticide. Insecticides can be applied with power hydraulic sprayers where access permits. Application costs are approximately $5-7 per tree. The insecticides carbaryl, acephate, and B.t. are available for application with ground based equipment.

Alternative 5. Sanitation and Salvage of Severly Damaged Stands. The removal of high risk and dead trees from infested stands may improve the appearance and allow the utilization of material from damaged stands. Where access exists, this material could be used for fuel wood. Provisions for regeneration may be needed where sanitation-salvage cutting destroys advanced regeneration.

RECOMMENDATIONS

The general recommendation for both the Pike and San Isabel, and the Arapaho and Roosevelt National Forests is Alternative 1. No Action. Considering the existing values of infested stands and the impacts of western spruce budworm, justification of large-scale suppression activities is unlikely. However, where persistent budworm populations have damaged stands, Alternative 5, Sanitation and Salvage may be appropriate. Should individual high value trees be located, Alternative 4, may be appropriate.

2/ Mention of commercial products is for convenience only and does not imply endorsement by the USDA.

LITERATURE CITED

McKnight, M.C. 1967. Ecology of the western spruce budowrm, *Choristoneura occidentalis* Freeman (Lepidoptera:Tortricidae) in Colorado. Colorado State University, Fort Collins, Colorado. Ph.D. Thesis, Entomology.